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<p>(21) International Application Number: PCT/GB99/00105  (22) International Filing Date: 13 January 1999 (13.01.99)  (30) Priority Data: 9801208.1 21 January 1998 (21.01.98) GB  (71) Applicant (for all designated States except US): MERCK SHARP &amp; DOHME LIMITED [GB/GB]; Hertford Road, Hoddesdon, Hertfordshire EN11 9BU (GB).  (72) Inventors; and (75) Inventors/Applicants (for US only): MADIN, Andrew [GB/GB]; Terlings Park, Eastwick Road, Harlow, Essex CM20 2QR (GB). OWENS, Andrew, Pate [GB/GB]; Terlings Park, Eastwick Road, Harlow, Essex CM20 2QR (GB).  (74) Agent: THOMPSON, John; Merck &amp; Co., Inc., European Patent Dept., Terlings Park, Eastwick Road, Harlow, Essex CM20 2QR (GB).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>
<p>(54) Title: TRIAZOLO-PYRIDAZINE DERIVATIVES AS LIGANDS FOR GABA RECEPTORS</p> <p>(57) Abstract</p> <p>A class of substituted 1,2,4-triazolo[4,3-<i>b</i>]pyridazine derivatives, possessing an optionally substituted cycloalkyl, phenyl or heteroaryl substituent at the 3-position and an amino moiety at the 6-position, are selective ligands for GABA<sub>A</sub> receptors, in particular having high affinity for the <math>\alpha 2</math> and/or <math>\alpha 3</math> subunit thereof, and are accordingly of benefit in the treatment and/or prevention of disorders of the central nervous system, including anxiety and convulsions.</p>		

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## TRIAZOLO-PYRIDAZINE DERIVATIVES AS LIGANDS FOR GABA RECEPTORS

5 The present invention relates to a class of substituted triazolo-  
pyridazine derivatives and to their use in therapy. More particularly, this  
invention is concerned with substituted 1,2,4-triazolo[4,3-*b*]pyridazine  
derivatives which are ligands for GABA<sub>A</sub> receptors and are therefore  
useful in the therapy of deleterious mental states.

10 Receptors for the major inhibitory neurotransmitter, gamma-  
aminobutyric acid (GABA), are divided into two main classes: (1) GABA<sub>A</sub>  
receptors, which are members of the ligand-gated ion channel superfamily;  
and (2) GABA<sub>B</sub> receptors, which may be members of the G-protein linked  
receptor superfamily. Since the first cDNAs encoding individual GABA<sub>A</sub>  
receptor subunits were cloned the number of known members of the  
15 mammalian family has grown to include at least six  $\alpha$  subunits, four  $\beta$   
subunits, three  $\gamma$  subunits, one  $\delta$  subunit, one  $\epsilon$  subunit and two  $\rho$   
subunits.

Although knowledge of the diversity of the GABA<sub>A</sub> receptor gene  
family represents a huge step forward in our understanding of this ligand-  
20 gated ion channel, insight into the extent of subtype diversity is still at an  
early stage. It has been indicated that an  $\alpha$  subunit, a  $\beta$  subunit and a  $\gamma$   
subunit constitute the minimum requirement for forming a fully  
functional GABA<sub>A</sub> receptor expressed by transiently transfecting cDNAs  
into cells. As indicated above,  $\delta$ ,  $\epsilon$  and  $\rho$  subunits also exist, but are  
25 present only to a minor extent in GABA<sub>A</sub> receptor populations.

Studies of receptor size and visualisation by electron microscopy  
conclude that, like other members of the ligand-gated ion channel family,  
the native GABA<sub>A</sub> receptor exists in pentameric form. The selection of at  
least one  $\alpha$ , one  $\beta$  and one  $\gamma$  subunit from a repertoire of seventeen allows  
30 for the possible existence of more than 10,000 pentameric subunit  
combinations. Moreover, this calculation overlooks the additional

permutations that would be possible if the arrangement of subunits around the ion channel had no constraints (i.e. there could be 120 possible variants for a receptor composed of five different subunits).

Receptor subtype assemblies which do exist include, amongst many others,  $\alpha 1\beta 2\gamma 2$ ,  $\alpha 2\beta 2/3\gamma 2$ ,  $\alpha 3\beta \gamma 2/3$ ,  $\alpha 2\beta \gamma 1$ ,  $\alpha 5\beta 3\gamma 2/3$ ,  $\alpha 6\beta \gamma 2$ ,  $\alpha 6\beta \delta$  and  $\alpha 4\beta \delta$ . Subtype assemblies containing an  $\alpha 1$  subunit are present in most areas of the brain and are thought to account for over 40% of GABA<sub>A</sub> receptors in the rat. Subtype assemblies containing  $\alpha 2$  and  $\alpha 3$  subunits respectively are thought to account for about 25% and 17% of GABA<sub>A</sub> receptors in the rat. Subtype assemblies containing an  $\alpha 5$  subunit are expressed predominantly in the hippocampus and cortex and are thought to represent about 4% of GABA<sub>A</sub> receptors in the rat.

A characteristic property of all known GABA<sub>A</sub> receptors is the presence of a number of modulatory sites, one of which is the benzodiazepine (BZ) binding site. The BZ binding site is the most explored of the GABA<sub>A</sub> receptor modulatory sites, and is the site through which anxiolytic drugs such as diazepam and temazepam exert their effect. Before the cloning of the GABA<sub>A</sub> receptor gene family, the benzodiazepine binding site was historically subdivided into two subtypes, BZ1 and BZ2, on the basis of radioligand binding studies. The BZ1 subtype has been shown to be pharmacologically equivalent to a GABA<sub>A</sub> receptor comprising the  $\alpha 1$  subunit in combination with a  $\beta$  subunit and  $\gamma 2$ . This is the most abundant GABA<sub>A</sub> receptor subtype, and is believed to represent almost half of all GABA<sub>A</sub> receptors in the brain.

Two other major populations are the  $\alpha 2\beta \gamma 2$  and  $\alpha 3\beta \gamma 2/3$  subtypes. Together these constitute approximately a further 35% of the total GABA<sub>A</sub> receptor repertoire. Pharmacologically this combination appears to be equivalent to the BZ2 subtype as defined previously by radioligand binding, although the BZ2 subtype may also include certain  $\alpha 5$ -containing subtype assemblies. The physiological role of these subtypes has hitherto

been unclear because no sufficiently selective agonists or antagonists were known.

It is now believed that agents acting as BZ agonists at  $\alpha 1\beta 2$ ,  $\alpha 2\beta 2$  or  $\alpha 3\beta 2$  subunits will possess desirable anxiolytic properties. Compounds which are modulators of the benzodiazepine binding site of the GABA<sub>A</sub> receptor by acting as BZ agonists are referred to hereinafter as "GABA<sub>A</sub> receptor agonists". The  $\alpha 1$ -selective GABA<sub>A</sub> receptor agonists alpidem and zolpidem are clinically prescribed as hypnotic agents, suggesting that at least some of the sedation associated with known anxiolytic drugs which act at the BZ1 binding site is mediated through GABA<sub>A</sub> receptors containing the  $\alpha 1$  subunit. Accordingly, it is considered that GABA<sub>A</sub> receptor agonists which interact more favourably with the  $\alpha 2$  and/or  $\alpha 3$  subunit than with  $\alpha 1$  will be effective in the treatment of anxiety with a reduced propensity to cause sedation. Also, agents which are antagonists or inverse agonists at  $\alpha 1$  might be employed to reverse sedation or hypnosis caused by  $\alpha 1$  agonists.

The compounds of the present invention, being selective ligands for GABA<sub>A</sub> receptors, are therefore of use in the treatment and/or prevention of a variety of disorders of the central nervous system. Such disorders include anxiety disorders, such as panic disorder with or without agoraphobia, agoraphobia without history of panic disorder, animal and other phobias including social phobias, obsessive-compulsive disorder, stress disorders including post-traumatic and acute stress disorder, and generalized or substance-induced anxiety disorder; neuroses; convulsions; migraine; depressive or bipolar disorders, for example single-episode or recurrent major depressive disorder, dysthymic disorder, bipolar I and bipolar II manic disorders, and cyclothymic disorder; psychotic disorders including schizophrenia; neurodegeneration arising from cerebral ischemia; attention deficit hyperactivity disorder; and disorders of circadian rhythm, e.g. in subjects suffering from the effects of jet lag or shift work.

Further disorders for which selective ligands for GABA<sub>A</sub> receptors may be of benefit include pain and nociception; emesis, including acute, delayed and anticipatory emesis, in particular emesis induced by chemotherapy or radiation, as well as post-operative nausea and vomiting; eating disorders including anorexia nervosa and bulimia nervosa; premenstrual syndrome; muscle spasm or spasticity, e.g. in paraplegic patients; and hearing loss. Selective ligands for GABA<sub>A</sub> receptors may also be effective as pre-medication prior to anaesthesia or minor procedures such as endoscopy, including gastric endoscopy.

In DE-A-2741763, and in US Patents 4,260,755, 4,260,756 and 4,654,343, are described various classes of 1,2,4-triazolo[4,3-*b*]pyridazine derivatives which are alleged to be useful as anxiolytic agents. The compounds described in DE-A-2741763 and in US Patents 4,260,755 and 4,654,343 possess a phenyl substituent at the 6-position of the triazolo-pyridazine ring system. The compounds described in US Patent 4,260,756, meanwhile, possess a heteroaryl moiety at the 6- or 8-position. In none of these publications, however, is there any disclosure or suggestion of 1,2,4-triazolo[4,3-*b*]pyridazine derivatives wherein the substituent at the 6-position is attached through a directly linked nitrogen atom.

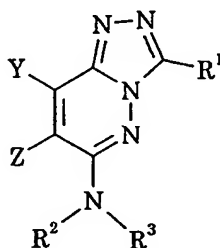
EP-A-0085840 and EP-A-0134946 describe related series of 1,2,4-triazolo[3,4-*a*]phthalazine derivatives which are stated to possess antianxiety activity. However, there is no disclosure nor any suggestion in either of these publications of replacing the benzo moiety of the triazolo-phthalazine ring system with any other functionality.

The present invention provides a class of triazolo-pyridazine derivatives which possess desirable binding properties at various GABA<sub>A</sub> receptor subtypes. The compounds in accordance with the present invention have good affinity as ligands for the  $\alpha 2$  and/or  $\alpha 3$  subunit of the human GABA<sub>A</sub> receptor. The compounds of this invention may interact more favourably with the  $\alpha 2$  and/or  $\alpha 3$  subunit than with the  $\alpha 1$  subunit. Desirably, the compounds of the invention will exhibit functional

selectivity in terms of a selective efficacy for the  $\alpha 2$  and/or  $\alpha 3$  subunit relative to the  $\alpha 1$  subunit.

The compounds of the present invention are GABA<sub>A</sub> receptor subtype ligands having a binding affinity ( $K_i$ ) for the  $\alpha 2$  and/or  $\alpha 3$  subunit, as measured in the assay described hereinbelow, of 100 nM or less, typically of 50 nM or less, and ideally of 10 nM or less. The compounds in accordance with this invention may possess at least a 2-fold, suitably at least a 5-fold, and advantageously at least a 10-fold, selective affinity for the  $\alpha 2$  and/or  $\alpha 3$  subunit relative to the  $\alpha 1$  subunit. However, compounds which are not selective in terms of their binding affinity for the  $\alpha 2$  and/or  $\alpha 3$  subunit relative to the  $\alpha 1$  subunit are also encompassed within the scope of the present invention; such compounds will desirably exhibit functional selectivity in terms of a selective efficacy for the  $\alpha 2$  and/or  $\alpha 3$  subunit relative to the  $\alpha 1$  subunit.

The present invention provides a compound of formula I, or a salt or prodrug thereof:



(I)

wherein

Y represents hydrogen or C<sub>1-6</sub> alkyl;

Z represents C<sub>1-6</sub> alkyl, C<sub>3-7</sub> cycloalkyl, C<sub>4-7</sub> cycloalkenyl, aryl, C<sub>3-7</sub> heterocycloalkyl, heteroaryl or di(C<sub>1-6</sub>)alkylamino, any of which groups may be optionally substituted;

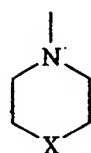
R<sup>1</sup> represents C<sub>3-7</sub> cycloalkyl, phenyl, furyl, thienyl or pyridinyl, any of which groups may be optionally substituted;

R<sup>2</sup> represents hydrogen or C<sub>1-6</sub> alkyl; and

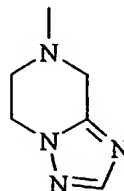
5 R<sup>3</sup> represents hydrogen; or C<sub>1-6</sub> alkyl, C<sub>3-7</sub> cycloalkyl(C<sub>1-6</sub>)alkyl, propargyl, aryl(C<sub>1-6</sub>)alkyl, C<sub>3-7</sub> heterocycloalkyl(C<sub>1-6</sub>)alkyl or heteroaryl(C<sub>1-6</sub>)alkyl, any of which groups may be optionally substituted; or

R<sup>2</sup> and R<sup>3</sup> are taken together with the intervening nitrogen atom to form a ring of formula (a) or (b):

10



(a)



(b)

wherein

X represents oxygen, sulphur or N-R<sup>4</sup>, in which

15 R<sup>4</sup> represents hydrogen or C<sub>1-6</sub> alkyl.

The groups Z, R<sup>1</sup> and R<sup>3</sup> may be unsubstituted, or substituted by one or more, suitably by one or two, substituents. In general, the groups Z, R<sup>1</sup> and R<sup>3</sup> will be unsubstituted or monosubstituted. Examples of optional substituents on the groups Z, R<sup>1</sup> and R<sup>3</sup> include C<sub>1-6</sub> alkyl, 20 aryl(C<sub>1-6</sub>)alkyl, pyridyl(C<sub>1-6</sub>)alkyl, halogen, halo(C<sub>1-6</sub>)alkyl, cyano, cyano(C<sub>1-6</sub>)alkyl, oxo, hydroxy, hydroxymethyl, C<sub>1-6</sub> alkoxy, C<sub>3-7</sub> cycloalkyl(C<sub>1-6</sub>)alkoxy, C<sub>3-7</sub> cycloalkoxy, amino, C<sub>1-6</sub> alkylamino, di(C<sub>1-6</sub>)alkylamino, amino(C<sub>1-6</sub>)alkyl, di(C<sub>1-6</sub>)alkylamino(C<sub>1-6</sub>)alkyl, di(C<sub>1-6</sub>)alkylaminocarbonyl(C<sub>1-6</sub>)alkyl, N-(C<sub>1-6</sub>)alkylpiperidinyl, 25 pyrrolidinyl(C<sub>1-6</sub>)alkyl, piperazinyl(C<sub>1-6</sub>)alkyl, morpholinyl(C<sub>1-6</sub>)alkyl, di(C<sub>1-6</sub>)alkylmorpholinyl(C<sub>1-6</sub>)alkyl and imidazolyl(C<sub>1-6</sub>)alkyl.



Representative substituents include C<sub>1-6</sub> alkyl, halogen, oxo, C<sub>1-6</sub> alkoxy and di(C<sub>1-6</sub>)alkylamino.

As used herein, the expression "C<sub>1-6</sub> alkyl" includes methyl and ethyl groups, and straight-chained or branched propyl, butyl, pentyl and  
5 hexyl groups. Particular alkyl groups are methyl, ethyl, *n*-propyl, isopropyl, *tert*-butyl and 1,1-dimethylpropyl. Derived expressions such as "C<sub>1-6</sub> alkoxy" are to be construed accordingly.

Typical C<sub>3-7</sub> cycloalkyl groups include cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl.

10 The expression "C<sub>3-7</sub> cycloalkyl(C<sub>1-6</sub>)alkyl" as used herein includes cyclopropylmethyl, cyclobutylmethyl, cyclopentylmethyl and cyclohexylmethyl.

Typical C<sub>4-7</sub> cycloalkenyl groups include cyclobutenyl, cyclopentenyl and cyclohexenyl.

15 Typical aryl groups include phenyl and naphthyl, preferably phenyl.

The expression "aryl(C<sub>1-6</sub>)alkyl" as used herein includes benzyl, phenylethyl, phenylpropyl and naphthylmethyl.

Suitable heterocycloalkyl groups include azetidiny, pyrrolidinyl, piperidinyl, piperazinyl, morpholinyl and thiomorpholinyl groups.

20 The expression "C<sub>3-7</sub> cycloalkyl(C<sub>1-6</sub>)alkyl" as used herein includes pyrrolidinylethyl, piperazinylethyl, morpholinylethyl, pyrrolidinylpropyl and morpholinylpropyl.

Suitable heteroaryl groups include pyridinyl, quinolinyl, isoquinolinyl, pyridazinyl, pyrimidinyl, pyrazinyl, quinoxalinyl, furyl, benzofuryl, dibenzofuryl, thienyl, benzthienyl, pyrrolyl, indolyl, pyrazolyl,  
25 indazolyl, oxazolyl, isoxazolyl, thiazolyl, isothiazolyl, imidazolyl, benzimidazolyl, oxadiazolyl, thiadiazolyl, triazolyl and tetrazolyl groups.

The expression "heteroaryl(C<sub>1-6</sub>)alkyl" as used herein includes furylmethyl, furylethyl, thienylmethyl, thienylethyl, pyrazolylmethyl,  
30 oxazolylmethyl, oxazolylethyl, isoxazolylmethyl, thiazolylmethyl, thiazolylethyl, imidazolylmethyl, imidazolylethyl, imidazolylpropyl,

benzimidazolymethyl, oxadiazolymethyl, oxadiazolyethyl,  
thiadiazolymethyl, thiadiazolyethyl, triazolymethyl, triazolylethyl,  
tetrazolymethyl, tetrazolyethyl, pyridinylmethyl, pyridinyethyl,  
pyridazinylmethyl, pyrimidinylmethyl, pyrazinylmethyl,  
5 quinolinylmethyl, isoquinolinylmethyl and quinoxalinylmethyl.

The term "halogen" as used herein includes fluorine, chlorine,  
bromine and iodine, especially fluorine or chlorine.

For use in medicine, the salts of the compounds of formula I will be  
pharmaceutically acceptable salts. Other salts may, however, be useful in  
10 the preparation of the compounds according to the invention or of their  
pharmaceutically acceptable salts. Suitable pharmaceutically acceptable  
salts of the compounds of this invention include acid addition salts which  
may, for example, be formed by mixing a solution of the compound  
according to the invention with a solution of a pharmaceutically acceptable  
15 acid such as hydrochloric acid, sulphuric acid, methanesulphonic acid,  
fumaric acid, maleic acid, succinic acid, acetic acid, benzoic acid, oxalic  
acid, citric acid, tartaric acid, carbonic acid or phosphoric acid.

Furthermore, where the compounds of the invention carry an acidic  
moiety, suitable pharmaceutically acceptable salts thereof may include  
20 alkali metal salts, e.g. sodium or potassium salts; alkaline earth metal  
salts, e.g. calcium or magnesium salts; and salts formed with suitable  
organic ligands, e.g. quaternary ammonium salts.

The present invention includes within its scope prodrugs of the  
compounds of formula I above. In general, such prodrugs will be  
25 functional derivatives of the compounds of formula I which are readily  
convertible *in vivo* into the required compound of formula I. Conventional  
procedures for the selection and preparation of suitable prodrug  
derivatives are described, for example, in *Design of Prodrugs*, ed. H.  
Bundgaard, Elsevier, 1985.

30 Where the compounds according to the invention have at least one  
asymmetric centre, they may accordingly exist as enantiomers. Where the

compounds according to the invention possess two or more asymmetric centres, they may additionally exist as diastereoisomers. It is to be understood that all such isomers and mixtures thereof in any proportion are encompassed within the scope of the present invention.

5 Suitably, Y represents hydrogen or methyl, especially hydrogen.

Examples of suitable values for the substituent Z include methyl, ethyl, isopropyl, *tert*-butyl, 1,1-dimethylpropyl, methyl-cyclopropyl, cyclobutyl, methyl-cyclobutyl, cyclopentyl, methyl-cyclopentyl, cyclohexyl, cyclobutenyl, phenyl, pyrrolidinyl, methyl-pyrrolidinyl, piperidinyl, 10 morpholinyl, thiomorpholinyl, pyridinyl, furyl, thienyl, chloro-thienyl and diethylamino.

In a particular embodiment, the substituent Z represents C<sub>3-7</sub> cycloalkyl, either unsubstituted or substituted by C<sub>1-6</sub> alkyl, especially methyl. Favourably, Z represents cyclobutyl.

15 Examples of typical optional substituents on the group R<sup>1</sup> include methyl, fluoro and methoxy.

Representative values of R<sup>1</sup> include cyclopropyl, phenyl, methylphenyl, fluorophenyl, difluorophenyl, methoxyphenyl, furyl, thienyl, methyl-thienyl and pyridinyl. Suitably, R<sup>1</sup> may represent 20 unsubstituted or monosubstituted phenyl. More particularly, R<sup>1</sup> represents phenyl.

Suitably, R<sup>2</sup> represents hydrogen or methyl.

Suitable values for the substituent R<sup>3</sup> in the compounds according to the invention include hydrogen; and methyl, ethyl, propyl, butyl, 25 cyclohexylmethyl, propargyl, benzyl, pyrrolidinyloethyl, piperazinyloethyl, morpholinylethyl, pyrrolidinylpropyl, morpholinylpropyl, pyrazolylmethyl, isoxazolylmethyl, thiazolylmethyl, thiazolyloethyl, imidazolylmethyl, imidazolylpropyl, benzimidazolylmethyl, oxadiazolylmethyl, triazolylmethyl, tetrazolylmethyl, pyridinylmethyl, pyridinyloethyl, 30 pyridazinylmethyl, pyrimidinylmethyl, pyrazinylmethyl, quinolinylmethyl, isoquinolinylmethyl and quinoxalinylmethyl, any of

which groups may be optionally substituted by one or more substituents. Typical values of R<sup>3</sup> include hydrogen; and methyl, ethyl, propyl, pyrrolidinylethyl, piperazinylethyl, morpholinylethyl, pyrrolidinylpropyl, morpholinylpropyl, imidazolylpropyl, triazolylmethyl, pyridinylmethyl and pyridinylethyl, any of which groups may be optionally substituted by one or more substituents.

Examples of suitable optional substituents on the group R<sup>3</sup> include C<sub>1-6</sub> alkyl, aryl(C<sub>1-6</sub>)alkyl, pyridyl(C<sub>1-6</sub>)alkyl, halogen, halo(C<sub>1-6</sub>)alkyl, cyano, cyano(C<sub>1-6</sub>)alkyl, oxo, hydroxymethyl, C<sub>1-6</sub> alkoxy, C<sub>3-7</sub> cycloalkyl(C<sub>1-6</sub>)alkoxy, di(C<sub>1-6</sub>)alkylamino, amino(C<sub>1-6</sub>)alkyl, di(C<sub>1-6</sub>)alkylamino(C<sub>1-6</sub>)alkyl, di(C<sub>1-6</sub>)alkylaminocarbonyl(C<sub>1-6</sub>)alkyl, N-(C<sub>1-6</sub>)alkylpiperidinyl, pyrrolidinyl(C<sub>1-6</sub>)alkyl, piperazinyl(C<sub>1-6</sub>)alkyl, morpholinyl(C<sub>1-6</sub>)alkyl and di(C<sub>1-6</sub>)alkylmorpholinyl(C<sub>1-6</sub>)alkyl. Typical substituents include C<sub>1-6</sub> alkyl, aryl(C<sub>1-6</sub>)alkyl, halogen, cyano, oxo, hydroxymethyl, C<sub>1-6</sub> alkoxy, C<sub>3-7</sub> cycloalkyl(C<sub>1-6</sub>)alkoxy and di(C<sub>1-6</sub>)alkylamino, especially C<sub>1-6</sub> alkyl, oxo, C<sub>1-6</sub> alkoxy or di(C<sub>1-6</sub>)alkylamino.

Specific illustrations of particular substituents on the group R<sup>3</sup> include methyl, ethyl, *n*-propyl, benzyl, pyridinylmethyl, chloro, chloromethyl, cyano, cyanomethyl, oxo, hydroxymethyl, methoxy, ethoxy, cyclopropylmethoxy, dimethylamino, dimethylaminomethyl, aminoethyl, dimethylaminoethyl, dimethylaminocarbonylmethyl, N-methylpiperidinyl, pyrrolidinylethyl, piperazinylethyl, morpholinylmethyl and dimethylmorpholinylmethyl, especially methyl, oxo, methoxy or dimethylamino.

Representative values of R<sup>3</sup> include hydrogen, methyl, cyanomethyl, methoxyethyl, dimethylaminoethyl, dimethylaminopropyl, hydroxybutyl, hydroxymethyl-cyclohexylmethyl, propargyl, dimethylaminomethyl-propargyl, dimethylmorpholinylmethyl-propargyl, cyanobenzyl, hydroxymethyl-benzyl, methyl-pyrrolidinylethyl, piperazinylethyl, morpholinylethyl, pyrrolidinylpropyl, pyrrolidinonylpropyl,

morpholinylpropyl, pyrazolylmethyl, dimethyl-pyrazolylmethyl, methyl-isoxazolylmethyl, thiazolylmethyl, methyl-thiazolylmethyl, ethyl-thiazolylmethyl, methyl-thiazolyethyl, imidazolylmethyl, methyl-imidazolylmethyl, ethyl-imidazolylmethyl, benzyl-imidazolylmethyl, 5 imidazolylpropyl, benzimidazolylmethyl, methyl-oxadiazolylmethyl, triazolylmethyl, methyl-triazolylmethyl, propyl-triazolylmethyl, benzyl-triazolylmethyl, pyridinylmethyl-triazolylmethyl, cyanomethyl-triazolylmethyl, dimethylaminomethyl-triazolylmethyl, aminoethyl-triazolylmethyl, dimethylaminoethyl-triazolylmethyl, 10 dimethylaminocarbonylmethyl-triazolylmethyl, *N*-methylpiperidinyl-triazolylmethyl, pyrrolidinylethyl-triazolylmethyl, piperazinylethyl-triazolylmethyl, morpholinylethyl-triazolylmethyl, methyl-tetrazolylmethyl, pyridinylmethyl, methyl-pyridinylmethyl, dimethyl-pyridinylmethyl, ethoxy-pyridinylmethyl, cyclopropylmethoxy-pyridinylmethyl, pyridinylethyl, pyridazinylmethyl, chloro- 15 pyridazinylmethyl, pyrimidinylmethyl, pyrazinylmethyl, quinolinylmethyl, isoquinolinylmethyl and quinoxalinylmethyl.

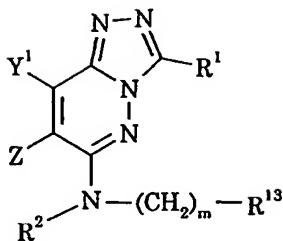
Particular values of  $R^3$  include hydrogen, methyl, methoxyethyl, dimethylaminoethyl, dimethylaminopropyl, methyl-pyrrolidinylethyl, 20 piperazinylethyl, morpholinylethyl, pyrrolidinylpropyl, pyrrolidinonylpropyl, morpholinylpropyl, imidazolylpropyl, methyl-triazolylmethyl, pyridinylmethyl and pyridinylethyl.

A favoured value of  $R^3$  is methyl-triazolylmethyl.

Suitably,  $R^4$  represents hydrogen or methyl.

25 Where  $R^2$  and  $R^3$  are taken together with the intervening nitrogen atom to form a ring of formula (a) as depicted above, the moiety X suitably represents oxygen.

A particular sub-class of compounds according to the invention is represented by the compounds of formula IIA, and salts and prodrugs 30 thereof:



(IIA)

wherein

Y¹ represents hydrogen or methyl;

5 Z, R¹ and R² are as defined with reference to formula I above;

m is 1, 2 or 3, preferably 1; and

R¹³ represents aryl or heteroaryl, either of which groups may be optionally substituted by one or more substituents.

Suitably, Y¹ represents hydrogen.

10 Examples of typical substituents on the group R¹³ include C₁-₆ alkyl, aryl(C₁-₆)alkyl, pyridyl(C₁-₆)alkyl, halogen, cyano, cyano(C₁-₆)alkyl, hydroxymethyl, C₁-₆ alkoxy, C₃-₇ cycloalkyl(C₁-₆)alkoxy, di(C₁-₆)alkylamino(C₁-₆)alkyl, amino(C₁-₆)alkyl, di(C₁-₆)alkylaminocarbonyl(C₁-₆)alkyl, N-(C₁-₆)alkylpiperidinyl, 15 pyrrolidinyl(C₁-₆)alkyl, piperazinyl(C₁-₆)alkyl and morpholinyl(C₁-₆)alkyl, especially C₁-₆ alkyl or C₁-₆ alkoxy.

20 Illustrative values of specific substituents on the group R¹³ include methyl, ethyl, *n*-propyl, benzyl, pyridinylmethyl, chloro, cyano, cyanomethyl, hydroxymethyl, methoxy, ethoxy, cyclopropylmethoxy, dimethylaminomethyl, aminoethyl, dimethylaminoethyl, dimethylaminocarbonylmethyl, N-methylpiperidinyl, pyrrolidinylethyl, piperazinylethyl and morpholinylmethyl, especially methyl.

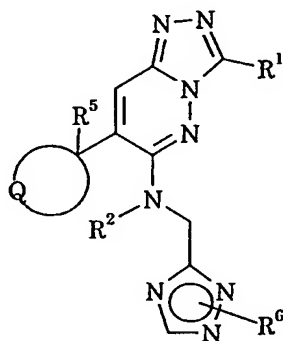
25 Particular values of R¹³ include cyanophenyl, hydroxymethyl-phenyl, pyrazolyl, dimethyl-pyrazolyl, methyl-isoxazolyl, thiazolyl, methyl-thiazolyl, ethyl-thiazolyl, imidazolyl, methyl-imidazolyl, ethyl-imidazolyl, benzyl-imidazolyl, benzimidazolyl, methyl-oxadiazolyl, triazolyl, methyl-

triazolyl, propyl-triazolyl, benzyl-triazolyl, pyridinylmethyl-triazolyl, cyanomethyl-triazolyl, dimethylaminomethyl-triazolyl, aminoethyl-triazolyl, dimethylaminoethyl-triazolyl, dimethylaminocarbonylmethyl-triazolyl, *N*-methylpiperidinyl-triazolyl, pyrrolidinylethyl-triazolyl, 5 piperazinylethyl-triazolyl, morpholinylethyl-triazolyl, methyl-tetrazolyl, pyridinyl, methyl-pyridinyl, dimethyl-pyridinyl, ethoxy-pyridinyl, cyclopropylmethoxy-pyridinyl, pyridazinyl, chloro-pyridazinyl, pyrimidinyl, pyrazinyl, quinolinyl, isoquinolinyl and quinoxalinyl.

Specific values of R<sup>13</sup> include imidazolyl, methyl-triazolyl and 10 pyridinyl.

A favoured value of R<sup>13</sup> is methyl-triazolyl.

A particular subset of the compounds of formula IIA above is represented by the compounds of formula IIB, and pharmaceutically acceptable salts thereof:



(IIB)

wherein

R<sup>1</sup> and R<sup>2</sup> are as defined with reference to formula I above;

20 Q represents the residue of a cyclopropyl, cyclobutyl, cyclopentyl or cyclohexyl ring;

R<sup>5</sup> represents hydrogen or methyl; and

R<sup>6</sup> represents hydrogen or methyl.

In relation to formula IIB above, R<sup>1</sup> suitably represents phenyl.

In a favoured embodiment, Q suitably represents the residue of a cyclobutyl ring.

Suitably, R<sup>5</sup> represents hydrogen.

Suitably, R<sup>6</sup> represents methyl.

5 Specific compounds within the scope of the present invention include:

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-(1-methyl-1*H*-1,2,4-triazol-3-ylmethyl)amine;

10 *N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N,N*-dimethylamine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-methyl-*N*-(1-methyl-1*H*-1,2,4-triazol-3-ylmethyl)amine;

7-cyclobutyl-6-(5,6-dihydro-8*H*-1,2,4-triazolo[1,5-*a*]pyrazin-7-yl)-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazine;

15 7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-ylamine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-methylamine;

7-cyclobutyl-6-(morpholin-4-yl)-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazine;

20 *N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-(2-methoxyethyl)amine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-(pyridin-2-ylmethyl)amine;

*N'*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N,N*-dimethylethane-1,2-diamine;

25 *N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[3-(morpholin-4-yl)propyl]amine;

(±)-*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[2-(1-methylpyrrolidin-2-yl)ethyl]amine;

30 *N'*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N,N*-dimethylpropane-1,3-diamine;



*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[3-(imidazol-1-yl)propyl]amine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[3-(pyrrolidin-1-yl)propyl]amine;

5 1-[3-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-ylamino)-propyl]pyrrolidin-2-one;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[3-(piperazin-1-yl)ethyl]amine;

10 *N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[2-(morpholin-4-yl)ethyl]amine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[2-(pyridin-2-yl)ethyl]amine;

and salts and prodrugs thereof.

Also provided by the present invention is a method for the  
15 treatment and/or prevention of anxiety which comprises administering to a patient in need of such treatment an effective amount of a compound of formula I as defined above or a pharmaceutically acceptable salt thereof or a prodrug thereof.

Further provided by the present invention is a method for the  
20 treatment and/or prevention of convulsions (e.g. in a patient suffering from epilepsy or a related disorder) which comprises administering to a patient in need of such treatment an effective amount of a compound of formula I as defined above or a pharmaceutically acceptable salt thereof or a prodrug thereof.

25 The binding affinity ( $K_i$ ) of the compounds according to the present invention for the  $\alpha 3$  subunit of the human GABA<sub>A</sub> receptor is conveniently as measured in the assay described hereinbelow. The  $\alpha 3$  subunit binding affinity ( $K_i$ ) of the compounds according to the invention is ideally 10 nM or less, preferably 2 nM or less, and more preferably 1 nM or less.

30 The compounds according to the present invention will ideally elicit at least a 40%, preferably at least a 50%, and more preferably at least a

60%, potentiation of the GABA EC<sub>20</sub> response in stably transfected recombinant cell lines expressing the  $\alpha$ 3 subunit of the human GABA<sub>A</sub> receptor. Moreover, the compounds of the invention will ideally elicit at most a 30%, preferably at most a 20%, and more preferably at most a 10%,  
5 potentiation of the GABA EC<sub>20</sub> response in stably transfected recombinant cell lines expressing the  $\alpha$ 1 subunit of the human GABA<sub>A</sub> receptor.

The potentiation of the GABA EC<sub>20</sub> response in stably transfected cell lines expressing the  $\alpha$ 3 and  $\alpha$ 1 subunits of the human GABA<sub>A</sub> receptor can conveniently be measured by procedures analogous to the protocol  
10 described in Wafford *et al.*, *Mol. Pharmacol.*, 1996, 50, 670-678. The procedure will suitably be carried out utilising cultures of stably transfected eukaryotic cells, typically of stably transfected mouse Ltk-fibroblast cells.

The compounds according to the present invention exhibit anxiolytic  
15 activity, as may be demonstrated by a positive response in the elevated plus maze and conditioned suppression of drinking tests (cf. Dawson *et al.*, *Psychopharmacology*, 1995, 121, 109-117). Moreover, the compounds of the invention are substantially non-sedating, as may be confirmed by an appropriate result obtained from the response sensitivity (chain-pulling)  
20 test (cf. Bayley *et al.*, *J. Psychopharmacol.*, 1996, 10, 206-213).

The compounds according to the present invention may also exhibit anticonvulsant activity. This can be demonstrated by the ability to block pentylenetetrazole-induced seizures in rats and mice, following a protocol analogous to that described by Bristow *et al.* in *J. Pharmacol. Exp. Ther.*,  
25 1996, 279, 492-501.

In order to elicit their behavioural effects, the compounds of the invention will be brain-penetrant; in other words, these compounds will be capable of crossing the so-called "blood-brain barrier". Preferably, the compounds of the invention will be capable of exerting their beneficial  
30 therapeutic action following administration by the oral route.

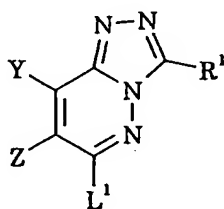
The invention also provides pharmaceutical compositions comprising one or more compounds of this invention in association with a pharmaceutically acceptable carrier. Preferably these compositions are in unit dosage forms such as tablets, pills, capsules, powders, granules, sterile parenteral solutions or suspensions, metered aerosol or liquid sprays, drops, ampoules, auto-injector devices or suppositories; for oral, parenteral, intranasal, sublingual or rectal administration, or for administration by inhalation or insufflation. For preparing solid compositions such as tablets, the principal active ingredient is mixed with a pharmaceutical carrier, e.g. conventional tableting ingredients such as corn starch, lactose, sucrose, sorbitol, talc, stearic acid, magnesium stearate, dicalcium phosphate or gums, and other pharmaceutical diluents, e.g. water, to form a solid preformulation composition containing a homogeneous mixture of a compound of the present invention, or a pharmaceutically acceptable salt thereof. When referring to these preformulation compositions as homogeneous, it is meant that the active ingredient is dispersed evenly throughout the composition so that the composition may be readily subdivided into equally effective unit dosage forms such as tablets, pills and capsules. This solid preformulation composition is then subdivided into unit dosage forms of the type described above containing from 0.1 to about 500 mg of the active ingredient of the present invention. Typical unit dosage forms contain from 1 to 100 mg, for example 1, 2, 5, 10, 25, 50 or 100 mg, of the active ingredient. The tablets or pills of the novel composition can be coated or otherwise compounded to provide a dosage form affording the advantage of prolonged action. For example, the tablet or pill can comprise an inner dosage and an outer dosage component, the latter being in the form of an envelope over the former. The two components can be separated by an enteric layer which serves to resist disintegration in the stomach and permits the inner component to pass intact into the duodenum or to be delayed in release. A variety of materials can be used for such enteric layers or coatings, such

materials including a number of polymeric acids and mixtures of polymeric acids with such materials as shellac, cetyl alcohol and cellulose acetate.

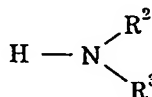
The liquid forms in which the novel compositions of the present invention may be incorporated for administration orally or by injection include aqueous solutions, suitably flavoured syrups, aqueous or oil suspensions, and flavoured emulsions with edible oils such as cottonseed oil, sesame oil, coconut oil or peanut oil, as well as elixirs and similar pharmaceutical vehicles. Suitable dispersing or suspending agents for aqueous suspensions include synthetic and natural gums such as tragacanth, acacia, alginate, dextran, sodium carboxymethylcellulose, methylcellulose, polyvinyl-pyrrolidone or gelatin.

In the treatment of anxiety, a suitable dosage level is about 0.01 to 250 mg/kg per day, preferably about 0.05 to 100 mg/kg per day, and especially about 0.05 to 5 mg/kg per day. The compounds may be administered on a regimen of 1 to 4 times per day.

The compounds of formula I as defined above may be prepared by a process which comprises reacting a compound of formula III with a compound of formula IV:



(III)



(IV)

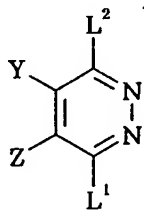
wherein Y, Z, R¹, R² and R³ are as defined above; and L¹ represents a suitable leaving group.

The leaving group L¹ is typically a halogen atom, especially chloro.

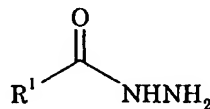
The reaction between compounds III and IV is conveniently effected by heating the reactants together in a sealed tube, optionally in a suitable

solvent such as *N,N*-dimethylformamide, methanol or 1,4-dioxane, and optionally in the presence of a base such as triethylamine. Where  $R^2$  and  $R^3$  together with the intervening nitrogen atom represent a ring of formula (b) as defined above, the reaction between compounds III and IV may  
5 conveniently be effected by stirring the reactants in an inert solvent, e.g. dimethyl sulphoxide, at an elevated temperature, typically in the region of 150°C.

The intermediates of formula III above may be prepared by reacting a compound of formula V with a substantially equimolar amount of a  
10 hydrazine derivative of formula VI:



(V)



(VI)

wherein Y, Z,  $R^1$  and  $L^1$  are as defined above, and  $L^2$  represents a suitable  
15 leaving group; followed, if necessary, by separation of the resulting mixture of isomers by conventional means.

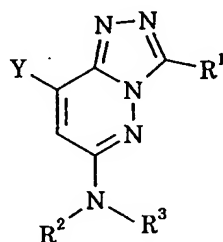
The leaving group  $L^2$  is typically a halogen atom, especially chloro. In the intermediates of formula V, the leaving groups  $L^1$  and  $L^2$  may be the same or different, but are suitably the same, preferably both chloro.

20 The reaction between compounds V and VI is conveniently effected by heating the reactants in the presence of a proton source such as triethylamine hydrochloride, typically at reflux in an inert solvent such as xylene or 1,4-dioxane.

Where Y and Z are different, the reaction between compounds V and  
25 VI will, as indicated above, usually give rise to a mixture of isomeric products depending upon whether the hydrazine derivative VI displaces

the leaving group  $L^1$  or  $L^2$ . Thus, in addition to the required product of formula III, the isomeric compound wherein the Y and Z moieties are reversed will usually be obtained to some extent. For this reason it will generally be necessary to separate the resulting mixture of isomers by conventional methods such as chromatography.

In another procedure, the compounds of formula I as defined above may be prepared by a process which comprises reacting a compound of formula  $Z\text{-CO}_2\text{H}$  with a compound of formula VII:



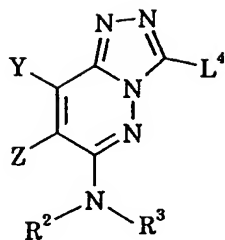
(VII)

wherein Y, Z,  $R^1$ ,  $R^2$  and  $R^3$  are as defined above; in the presence of silver nitrate and ammonium persulphate.

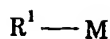
The reaction is conveniently carried out under acidic conditions in a suitable solvent, for example using sulphuric acid in water or aqueous acetonitrile, typically at an elevated temperature.

The intermediates of formula VII correspond to the compounds of formula I as defined above wherein Z is hydrogen, and they may therefore be prepared by methods analogous to those described above for preparing the corresponding compounds of formula I.

In a further procedure, the compounds of formula I as defined above may be prepared by a process which comprises reacting a compound of formula VIII with a compound of formula IX:



(VIII)



(IX)

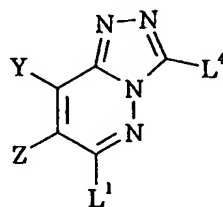
wherein Y, Z, R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are as defined above, M represents -B(OH)<sub>2</sub> or -Sn(Alk)<sub>3</sub> in which Alk represents a C<sub>1-6</sub> alkyl group, typically *n*-butyl, and  
 5 L<sup>4</sup> represents a suitable leaving group; in the presence of a transition metal catalyst.

The leaving group L<sup>4</sup> is suitably a halogen atom, e.g. bromo.

A suitable transition metal catalyst of use in the reaction between  
 10 compounds VIII and IX comprises dichlorobis(triphenylphosphine)-palladium(II) or tetrakis(triphenylphosphine)palladium(0).

The reaction between compounds VIII and IX is conveniently effected in an inert solvent such as *N,N*-dimethylformamide, typically at an elevated temperature.

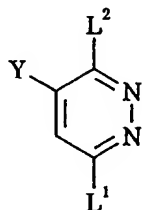
The intermediates of formula VIII may be prepared by reacting a  
 15 compound of formula IV as defined above with a compound of formula X:



(X)

wherein Y, Z, L<sup>1</sup> and L<sup>4</sup> are as defined above; under conditions analogous  
 20 to those described above for the reaction between compounds III and IV.

The intermediates of formula V above may be prepared by reacting a compound of formula Z-CO<sub>2</sub>H with a compound of formula XI:



(XI)

5

wherein Y, Z, L<sup>1</sup> and L<sup>2</sup> are as defined above; in the presence of silver nitrate and ammonium persulphate; under conditions analogous to those described above for the reaction between Z-CO<sub>2</sub>H and compound VII.

Where they are not commercially available, the starting materials  
10 of formula IV, VI, IX, X and XI may be prepared by methods analogous to those described in the accompanying Examples, or by standard methods well known from the art.

It will be understood that any compound of formula I initially obtained from any of the above processes may, where appropriate,  
15 subsequently be elaborated into a further compound of formula I by techniques known from the art. For example, a compound of formula I initially obtained wherein R<sup>3</sup> is unsubstituted may be converted into a corresponding compound wherein R<sup>3</sup> is substituted, typically by standard alkylation procedures, for example by treatment with a haloalkyl  
20 derivative in the presence of sodium hydride and *N,N*-dimethylformamide, or with a hydroxyalkyl derivative in the presence of triphenylphosphine and diethyl azodicarboxylate. Furthermore, a compound of formula I initially obtained wherein R<sup>3</sup> represents cyano(C<sub>1-6</sub>)alkyl may be converted  
25 into the corresponding 3-substituted 1,2,4-triazol-5-yl(C<sub>1-6</sub>)alkyl analogue by treatment with the appropriate acyl hydrazine derivative in the presence of a base such as sodium methoxide. Similarly, a compound of



formula I initially obtained wherein  $R^3$  represents an optionally substituted propargyl moiety may be converted into the corresponding 1,2,3-triazolylmethyl analogue by treatment with azide anion. A compound of formula I initially obtained wherein the  $R^3$  substituent is substituted by a halogen atom, e.g. chloro, may be converted into the corresponding compound wherein the  $R^3$  substituent is substituted by a di( $C_{1-6}$ )alkylamino moiety by treatment with the appropriate di( $C_{1-6}$ )alkylamine, typically with heating in a solvent such as 1,4-dioxane in a sealed tube.

Where the above-described processes for the preparation of the compounds according to the invention give rise to mixtures of stereoisomers, these isomers may be separated by conventional techniques such as preparative chromatography. The novel compounds may be prepared in racemic form, or individual enantiomers may be prepared either by enantiospecific synthesis or by resolution. The novel compounds may, for example, be resolved into their component enantiomers by standard techniques such as preparative HPLC, or the formation of diastereomeric pairs by salt formation with an optically active acid, such as (-)-di-*p*-toluoyl-d-tartaric acid and/or (+)-di-*p*-toluoyl-l-tartaric acid, followed by fractional crystallization and regeneration of the free base. The novel compounds may also be resolved by formation of diastereomeric esters or amides, followed by chromatographic separation and removal of the chiral auxiliary.

During any of the above synthetic sequences it may be necessary and/or desirable to protect sensitive or reactive groups on any of the molecules concerned. This may be achieved by means of conventional protecting groups, such as those described in *Protective Groups in Organic Chemistry*, ed. J.F.W. McOmie, Plenum Press, 1973; and T.W. Greene & P.G.M. Wuts, *Protective Groups in Organic Synthesis*, John Wiley & Sons, 1991. The protecting groups may be removed at a convenient subsequent stage using methods known from the art.

The following Examples illustrate the preparation of compounds according to the invention.

The compounds in accordance with this invention potentially inhibit the binding of [<sup>3</sup>H]-flumazenil to the benzodiazepine binding site of human GABA<sub>A</sub> receptors containing the  $\alpha 2$  or  $\alpha 3$  subunit stably expressed in Ltk-cells.

#### *Reagents*

- Phosphate buffered saline (PBS).
- 10 • Assay buffer: 10 mM KH<sub>2</sub>PO<sub>4</sub>, 100 mM KCl, pH 7.4 at room temperature.
- [<sup>3</sup>H]-Flumazenil (18 nM for  $\alpha 1\beta 3\gamma 2$  cells; 18 nM for  $\alpha 2\beta 3\gamma 2$  cells; 10 nM for  $\alpha 3\beta 3\gamma 2$  cells) in assay buffer.
- Flunitrazepam 100  $\mu$ M in assay buffer.
- Cells resuspended in assay buffer (1 tray to 10 ml).

15

#### *Harvesting Cells*

Supernatant is removed from cells. PBS (approximately 20 ml) is added. The cells are scraped and placed in a 50 ml centrifuge tube. The procedure is repeated with a further 10 ml of PBS to ensure that most of the cells are removed. The cells are pelleted by centrifuging for 20 min at 3000 rpm in a benchtop centrifuge, and then frozen if desired. The pellets are resuspended in 10 ml of buffer per tray (25 cm x 25 cm) of cells.

20

#### *Assay*

25 Can be carried out in deep 96-well plates or in tubes. Each tube contains:

- 300  $\mu$ l of assay buffer.
- 50  $\mu$ l of [<sup>3</sup>H]-flumazenil (final concentration for  $\alpha 1\beta 3\gamma 2$ : 1.8 nM; for  $\alpha 2\beta 3\gamma 2$ : 1.8 nM; for  $\alpha 3\beta 3\gamma 2$ : 1.0 nM).

Concentrated sulphuric acid (53.6 ml, 1.0 mol) was added carefully to a stirred suspension of 3,6-dichloropyridazine (50.0 g, 0.34 mol) in water (1.25 l). This mixture was then heated to 70°C (internal temperature) before the addition of cyclobutane carboxylic acid (35.3 ml, 0.37 mol). A

solution of silver nitrate (11.4 g, 0.07 mol) in water (20ml) was then added over approximately one minute. This caused the reaction mixture to become milky in appearance. A solution of ammonium persulphate (230 g, 1.0 mol) in water (0.63 l) was then added over 20-30 minutes. The internal temperature rose to approximately 85°C. During the addition the product formed as a sticky precipitate. Upon complete addition the reaction was stirred for an additional 5 minutes, then allowed to cool to room temperature. The mixture was then poured onto ice and basified with concentrated aqueous ammonia, with the addition of more ice as required to keep the temperature below 10°C. The aqueous phase was extracted with dichloromethane (x3). The combined extracts were dried (MgSO<sub>4</sub>), filtered and evaporated to give the title compound (55.7 g, 82%) as an oil. <sup>1</sup>H nmr (CDCl<sub>3</sub>) indicated contamination with approximately 5% of the 4,5-dicyclobutyl compound. However, this material was used without further purification. Data for the title compound: <sup>1</sup>H NMR (360 MHz, d<sub>6</sub>-DMSO) δ 1.79-1.90 (1H, m), 2.00-2.09 (1H, m), 2.18-2.30 (2H, m), 2.33-2.40 (2H, m), 3.63-3.72 (1H, m), 7.95 (1H, s); MS (ES<sup>+</sup>) m/e 203 [MH]<sup>+</sup>, 205 [MH]<sup>+</sup>, 207 [MH]<sup>+</sup>.

b) 6-Chloro-7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazine

A mixture of 3,6-dichloro-4-cyclobutylpyridazine from above (55.7 g, 0.27 mol), benzoic hydrazide (41.1 g, 0.30 mol) and triethylamine hydrochloride (41.5 g, 0.30 mol) in *p*-xylene (0.4 l) was stirred and heated at reflux under a stream of nitrogen for 24 hours. Upon cooling the volatiles were removed *in vacuo*. The residue was partitioned between dichloromethane and water. The aqueous was basified by the addition of solid potassium carbonate. Some dark insoluble material was removed by filtration at this stage. The aqueous phase was further extracted with dichloromethane (x2). The combined extracts were dried (MgSO<sub>4</sub>), filtered and evaporated. The residue was purified by chromatography on silica gel eluting with 5%→10%→25% ethyl acetate/dichloromethane to give the

title compound, (26.4 g, 34%) as an off-white solid. Data for the title compound:  $^1\text{H}$  NMR (360 MHz,  $\text{CDCl}_3$ )  $\delta$  1.90-2.00 (1H, m), 2.12-2.28 (3H, m), 2.48-2.57 (2H, m), 3.69-3.78 (1H, m), 7.49-7.59 (3H, m), 7.97 (1H, s), 8.45-8.48 (2H, m); MS ( $\text{ES}^+$ )  $m/e$  285  $[\text{MH}]^+$ , 287  $[\text{MH}]^+$ .

5

c) 3-Chloromethyl-1-methyl-1H-1,2,4-triazole

(1-Methyl-1H-1,2,4-triazol-3-yl)methanol (500 mg, 4.4 mmol)

(prepared using the conditions described in EP-A-421210) was added

portionwise to thionyl chloride (5 ml) at  $0^\circ\text{C}$ . Upon complete addition the

10 mixture was allowed to warm to room temperature, then heated at reflux for 45 minutes (gas evolution observed). Upon cooling the thionyl chloride was removed *in vacuo*. The residue was partitioned between

dichloromethane and aqueous sodium hydrogen carbonate. The aqueous phase was further extracted with dichloromethane (x2). The combined

15 extracts were dried ( $\text{Na}_2\text{SO}_4$ ), filtered and evaporated to give the title chloride (570 mg), as an oil. This material was used without further purification. Data for the title compound:  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ )  $\delta$  3.92 (3H, s), 4.63 (2H, s), 8.10 (1H, s). MS ( $\text{ES}^+$ )  $m/e$  133  $[\text{MH}]^+$ , 131  $[\text{MH}]^+$ .

20 d) C-(1-Methyl-1H-1,2,4-triazol-3-yl)methylamine Hydrochloride

A solution of 3-chloromethyl-1-methyl-1H-1,2,4-triazole (600 mg, 4.6 mmol) in aqueous ammonia (5 ml) was stirred and heated at  $80^\circ\text{C}$  for 16 hours in a sealed tube. Upon cooling the volatiles were removed *in vacuo* (azeotroping with ethanol) to give the title compound (600 mg, 92%) as a

25 colourless solid after drying under high vacuum.  $^1\text{H}$  NMR (250 MHz,  $d_6$ -DMSO)  $\delta$  3.88 (3H, s), 4.04 (2H, s), 8.3 (3H, br s), 8.58 (1H, s).

e) N-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazin-6-yl)-N-(1-methyl-1H-1,2,4-triazol-3-yl)methylamine and

30 N-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazin-6-yl)-N,N-dimethylamine

A mixture of 6-chloro-7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazine (144 mg, 0.52 mmol) and *C*-(1-methyl-1*H*-1,2,4-triazol-3-yl)methylamine hydrochloride (300 mg, 2.0 mmol) in triethylamine (1 ml) and dry DMF (1 ml) was stirred and heated at 100°C in a sealed tube for 20 hours. Upon cooling the volatiles were removed *in vacuo*, and the residue was partitioned between dichloromethane and saturated aqueous sodium hydrogen carbonate. The aqueous was further extracted with dichloromethane (x2). The combined extracts were dried (Na<sub>2</sub>SO<sub>4</sub>), filtered and evaporated. The residue was purified by chromatography on silica gel, eluting with 2%→5%→10% methanol-dichloromethane to give, in order of elution:

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N,N*-dimethylamine: <sup>1</sup>H NMR (360 MHz, CDCl<sub>3</sub>) δ 1.90-2.23 (4H, m), 2.44-2.52 (2H, m), 2.94 (6H, s), 3.66-3.74 (1H, m), 7.44-7.55 (3H, m), 7.90 (1H, s), 8.55 (2H, d, *J* = 8 Hz); MS (ES<sup>+</sup>) *m/e* 294 [MH]<sup>+</sup>; and

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-(1-methyl-1*H*-1,2,4-triazol-3-ylmethyl)amine: <sup>1</sup>H NMR (360 MHz, CDCl<sub>3</sub>) δ 1.96-2.02 (1H, m), 2.18-2.32 (3H, m), 2.50-2.56 (2H, m), 3.48-3.54 (1H, m), 3.94 (3H, s), 4.73 (2H, d, *J* = 4.6 Hz), 5.45 (1H, br s), 7.44-7.56 (3H, m), 7.69 (1H, d, *J* = 1.5 Hz), 8.02 (1H, s), 8.58 (2H, d, *J* = 8 Hz); MS (ES<sup>+</sup>) *m/e* 361 [MH]<sup>+</sup>.

## EXAMPLE 2

*N*-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-methyl-*N*-(1-methyl-1*H*-1,2,4-triazol-3-ylmethyl)amine Hydrochloride

### a) *N*-Methyl-*N*-(1-methyl-1*H*-1,2,4-triazol-3-ylmethyl)amine

A solution of 3-chloromethyl-1-methyl-1*H*-1,2,4-triazole (from Example 1, Step c; 600 mg, 4.6 mmol) in 40% aqueous methylamine and 1,4-dioxane (5 ml) was stirred and heated at 80°C in a sealed tube for 16 hours. Upon cooling the whole mixture was evaporated (azeotroping with

ethanol). The residue was purified by chromatography on silica gel, eluting with dichloromethane-methanol-aqueous ammonia (60:8:1→40:8:1) to give the title compound (440 mg, 80%) as a pale yellow oil. <sup>1</sup>H NMR (250 MHz, d<sub>6</sub>-DMSO) δ 3.61 (2H, s), 3.81 (3H, s), 8.35 (1H, s); MS (ES<sup>+</sup>) m/e 127 [MH]<sup>+</sup>.

b) N-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazin-6-yl)-N-methyl-N-(1-methyl-1H-1,2,4-triazol-3-ylmethyl)amine Hydrochloride

A mixture of 6-chloro-7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazine (100 mg, 0.35 mmol) and N-methyl-N-(1-methyl-1H-1,2,4-triazol-3-ylmethyl)amine (150 mg, 1.2 mmol) in triethylamine (1 ml) and dry DMF (1 ml) was stirred and heated at 100°C in a sealed tube for 16 hours. Upon cooling the volatiles were removed *in vacuo*, and the residue was partitioned between dichloromethane and saturated aqueous sodium hydrogen carbonate. The aqueous was further extracted with dichloromethane (x2). The combined extracts were dried (Na<sub>2</sub>SO<sub>4</sub>), filtered and evaporated. The residue was purified by chromatography on silica gel, eluting with 2%→5% methanol-dichloromethane to give the free base as an oil. Treatment with a solution of hydrogen chloride in methanol gave the title compound (40 mg, 30%) as a pale yellow solid. <sup>1</sup>H NMR (360 MHz, d<sub>6</sub>-DMSO) δ 1.86-1.92 (1H, m), 1.96-2.04 (1H, m), 2.20-2.32 (2H, m), 2.40-2.46 (2H, m), 2.97 (3H, s), 3.83 (3H, s), 4.42 (2H, s), 7.54-7.60 (3H, m), 8.26 (1H, s), 8.36 (2H, br d, *J* = 8 Hz), 8.48 (1H, s); MS (ES<sup>+</sup>) m/e 374 [MH]<sup>+</sup>.

EXAMPLE 3

7-Cyclobutyl-6-(5,6-dihydro-8H-1,2,4-triazolo[1,5-a]pyrazin-7-yl)-3-phenyl-1,2,4-triazolo[4,3-b]pyridazine

a) 2-(1,2,4-Triazol-1-yl)ethanol

2-Chloroethanol (50 ml, 0.75 mol) was added to a stirred suspension of 1,2,4-triazole, sodium salt (46 g, 0.5 mol) in dry methanol (300 ml) at room temperature under nitrogen. The mixture was then stirred and heated at reflux for 18 hours. Upon cooling, the reaction was quenched with water (50 ml). The methanol was then removed *in vacuo*. The residue was diluted with water (approx. 200 ml), and then extracted with ethyl acetate using a continuous extractor for 24 hours. The ethyl acetate was dried (Na<sub>2</sub>SO<sub>4</sub>), filtered and evaporated to give the title compound (12.8 g, 23%) as an oil. This material was used without further purification. <sup>1</sup>H NMR (360 MHz, d<sub>6</sub>-DMSO) δ 3.72-3.76 (2H, m), 4.19-4.22 (2H, m), 4.94 (1H, t, *J* = 5.4 Hz), 7.94 (1H, s), 8.44 (1H, s). MS (ES<sup>+</sup>) *m/e* 114 [MH]<sup>+</sup>.

b) 2-(5-Hydroxymethyl-1,2,4-triazol-1-yl)ethanol

A solution of 2-(1,2,4-triazol-1-yl)ethanol (5.0 g, 44 mmol) in 38% w/v aqueous formaldehyde (25 ml) was stirred and heated at 135°C in a sealed tube for 18 hours. Upon cooling the volatiles were removed *in vacuo* (azeotroping with ethanol). The residue was purified by chromatography on silica gel, eluting with 5→10→15% methanol-dichloromethane to give the title compound (4.3 g, 68%) as a thick oil. <sup>1</sup>H NMR (360 MHz, d<sub>6</sub>-DMSO) δ 3.69-3.74 (2H, m), 4.24 (2H, t, *J* = 5.7 Hz), 4.60 (2H, d, *J* = 5.7 Hz), 4.96 (1H, t, *J* = 5.3 Hz), 5.51 (1H, t, *J* = 5.8 Hz), 7.84 (1H, s); MS (ES<sup>+</sup>) *m/e* 144 [MH]<sup>+</sup>.

c) 5,6,7,8-Tetrahydro-1,2,4-triazolo[1,5-*a*]pyrazine

Thionyl chloride (20 ml) was added to 2-(5-hydroxymethyl-1,2,4-triazol-1-yl)ethanol (2.0 g, 14 mmol) at 0°C. The mixture was stirred and the cooling bath was removed. The clear solution was then stirred and heated at reflux. After 2 hours the reaction was allowed to cool, and the volatiles were removed *in vacuo*. The residue was then carefully treated



with cold saturated aqueous sodium hydrogen carbonate. The aqueous was extracted with dichloromethane (x3). The combined extracts were dried ( $\text{Na}_2\text{SO}_4$ ), filtered and evaporated to give the bis-chloride (2.5 g) as an oil. This material was used without further purification.

5           A solution of the bis-chloride, from above, in 1,4-dioxane (5 ml) and aqueous ammonia (15 ml) was stirred and heated at 80°C in a sealed tube for 4 hours. The volatiles were removed *in vacuo* to give the title compound as the hydrochloride salt (2.1 g, 90%). The free base was obtained after chromatography on silica gel, eluting with  
10 dichloromethane-methanol-aqueous ammonia (80:8:1).  $^1\text{H}$  NMR (250 MHz,  $d_6$ -DMSO)  $\delta$  3.1 (1H, br s), 3.34 (2H, t,  $J = 7.8$  Hz), 4.13 (2H, s), 4.25 (2H, t,  $J = 7.8$  Hz), 8.10 (1H, s); MS ( $\text{ES}^+$ )  $m/e$  125  $[\text{MH}]^+$ .

15           d) 7-Cyclobutyl-6-(5,6-dihydro-8H-1,2,4-triazolo[1,5- $\alpha$ ]pyrazin-7-yl)-3-phenyl-1,2,4-triazolo[4,3- $b$ ]pyridazine

          A mixture of 6-chloro-7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3- $b$ ]pyridazine (150 mg, 0.53 mmol) and 5,6,7,8-tetrahydro-1,2,4-triazolo[1,5- $\alpha$ ]pyrazine (190 mg, 1.53 mmol) in dimethyl sulphoxide (1 ml) was stirred and heated at 150°C for 20 hours. The mixture was partitioned between  
20 dichloromethane and water. The aqueous phase was further extracted with dichloromethane (x2). The combined extracts were dried ( $\text{Na}_2\text{SO}_4$ ), filtered and evaporated. The residue was purified by chromatography on silica gel, eluting with 3→4% methanol-dichloromethane to give the title compound (52 mg, 26%) as an off-white solid (after trituration with diethyl  
25 ether).  $^1\text{H}$  NMR (360 MHz,  $\text{CDCl}_3$ )  $\delta$  2.00-2.28 (4H, m), 2.48-2.55 (2H, m), 3.68-3.80 (3H, m), 4.43 (2H, t,  $J = 5.5$  Hz), 4.67 (2H, s), 7.46-7.56 (3H, m), 7.97 (1H, s), 8.09 (1H, s), 8.37 (2H, br d,  $J = 8$  Hz); MS ( $\text{ES}^+$ )  $m/e$  373  $[\text{MH}]^+$ .

EXAMPLE 47-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-ylamine

6-Chloro-7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazine (200  
5 mg, 0.70 mmol) was suspended in methanol (8 ml). The mixture was  
saturated with ammonia and heated in a sealed tube at 50°C overnight.  
The mixture was evaporated *in vacuo*, triturated (diethyl ether/hexane)  
and dried to give the title compound. <sup>1</sup>H NMR (360 MHz, d<sub>6</sub>-DMSO) δ  
1.82-1.87 (1H, m), 1.99-2.35 (5H, m), 3.54-3.64 (1H, m), 7.34 (2H, vbs),  
10 7.48-7.62 (3H, m), 8.08 (1H, s), 8.41 (2H, d, *J* = 7.1 Hz); MS (ES<sup>+</sup>) *m/e* 266  
[MH]<sup>+</sup>.

EXAMPLE 5

15 *N*-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-  
methylamine

The title compound was prepared using an analogous procedure to  
that described in Example 4. MS (ES<sup>+</sup>) *m/e* 280 [MH]<sup>+</sup>.

20 EXAMPLE 6

7-Cyclobutyl-6-(morpholin-4-yl)-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazine

6-Chloro-7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazine (100  
mg, 0.35 mmol), morpholine (154 mg, 1.8 mmol) and triethylamine (178  
25 mg, 1.8 mmol) were heated in 1,4 dioxane (6 ml) in a sealed tube at 90°C  
for 24 h. The reaction mixture was partitioned (ethyl acetate/water). The  
organic layer was washed (water, brine), dried (MgSO<sub>4</sub>) and was  
evaporated *in vacuo*. The residue was purified by chromatography on  
silica gel, eluting with ethyl acetate to give the title compound. <sup>1</sup>H NMR  
30 (250 MHz, CDCl<sub>3</sub>) δ 1.96-2.88 (1H, m), 2.48 (2H, m), 3.25-3.28 (4H, m),

3.70-3.76 (1H, m), 3.90-3.94 (4H, m), 7.52-7.55 (3H, m), 7.98 (1H, s), 8.49 (2H, s); MS (ES<sup>+</sup>) m/e 336 [MH]<sup>+</sup>.

#### EXAMPLE 7

5

N-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazin-6-yl)-N-(2-methoxyethyl)amine

The title compound was prepared using an analogous procedure to that described in Example 6. <sup>1</sup>H NMR (360 MHz, CDCl<sub>3</sub>) δ 1.97 (1H, m),  
10 2.20-2.25 (3H, m), 2.44-2.46 (2H, m), 3.41 (4H, s), 3.64-3.70 (4H, m), 4.88 (1H, bs), 7.43-7.53 (3H, m), 7.65 (1H, s), 8.51 (2H, d, *J* = 7.0 Hz).

#### EXAMPLE 8

15 N-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazin-6-yl)-N-(pyridin-2-ylmethyl)amine

The title compound was prepared using an analogous procedure to that described in Example 6. <sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>) δ 2.00-2.05 (1H, m), 2.25-2.31 (3H, m), 2.55-2.61 (2H, m), 3.55-3.61 (1H, sm), 4.73 (2H, d, *J* = 4.2 Hz), 6.40 (1H, vbs), 7.24-7.29 (1H, m), 7.35-7.58 (4H, m), 7.68-7.76 (2H, m), 8.50-8.68 (3H, m); MS (ES<sup>+</sup>) m/e 357 [MH]<sup>+</sup>.  
20

#### EXAMPLE 9

25 N-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazin-6-yl)-N,N-dimethylethane-1,2-diamine

6-Chloro-7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazine (100 mg, 0.35 mmol) and *N,N*-dimethylethylenediamine were heated together in a sealed tube at 60°C for 24 h. The mixture was cooled and the white  
30 precipitate was collected by filtration and washed with diethyl ether, then dried to give the title compound. <sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>) δ 1.94 (1H,

m), 2.12-2.24 (3H, m), 2.29 (6H, s), 2.41-2.50 (2H, m), 2.59-2.64 (2H, m), 3.38-3.49 (3H, m), 5.51 (1H, vbs), 7.41-7.52 (3H, m), 7.62 (1H, m), 8.54-8.62 (2H, m); MS (ES<sup>+</sup>) m/e 337 [MH]<sup>+</sup>.

5

**EXAMPLE 10**

*N*-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[3-(morpholin-4-yl)propyl]amine

10 The title compound was prepared using an analogous procedure to that described in Example 9. <sup>1</sup>H NMR (250 MHz, d<sub>6</sub>-DMSO) δ 1.48-2.42 (12H, m), 3.49-3.57 (9H, m), 6.70 (1H, m), 7.49-7.60 (3H, m), 7.82 (1H, s), 8.45-8.48 (2H, m); MS (ES<sup>+</sup>) m/e 393 [MH]<sup>+</sup>.

**EXAMPLE 11**

15

(±)-*N*-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[2-(1-methylpyrrolidin-2-yl)ethyl]amine

20 The title compound was prepared using an analogous procedure to that described in Example 9. <sup>1</sup>H NMR (250 MHz, d<sub>6</sub>-DMSO) δ 1.55-2.18 (12H, m), 2.24 (3H, s), 2.38 (2H, m), 2.95 (1H, m), 3.40-3.49 (3H, m), 6.96 (1H, m), 7.49-7.58 (3H, m), 7.82 (1H, s), 8.46-8.52 (2H, m); MS (ES<sup>+</sup>) m/e 377 [MH]<sup>+</sup>.

**EXAMPLE 12**

25

*N'*-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N,N*-dimethylpropane-1,3-diamine

30 The title compound was prepared using an analogous procedure to that described in Example 9. <sup>1</sup>H NMR (250 MHz, CDCl<sub>3</sub>) δ 1.82-2.03 (2H, m), 2.06-2.23 (2H, m), 2.34 (6H, s), 2.40-2.57 (4H, m), 3.21-3.31 (1H, m),

3.51-3.58 (2H, m), 7.16 (1H, vbs), 7.40-7.55 (3H, m), 7.63 (1H, m), 8.52-8.62 (2H, m); MS (ES<sup>+</sup>) m/e 351 [MH]<sup>+</sup>.

### EXAMPLE 13

5

N-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazin-6-yl)-N-[3-(imidazol-1-yl)propyl]amine

The title compound was prepared using an analogous procedure to that described in Example 9. MS (ES<sup>+</sup>) m/e 374 [MH]<sup>+</sup>.

10

### EXAMPLE 14

N-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazin-6-yl)-N-[3-(pyrrolidin-1-yl)propyl]amine

15

The title compound was prepared using an analogous procedure to that described in Example 9. MS (ES<sup>+</sup>) m/e 377 [MH]<sup>+</sup>.

### EXAMPLE 15

20

1-[3-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazin-6-ylamino)-propyl]pyrrolidin-2-one

The title compound was prepared using an analogous procedure to that described in Example 9. MS (ES<sup>+</sup>) m/e 391 [MH]<sup>+</sup>.

25

### EXAMPLE 16

N-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-b]pyridazin-6-yl)-N-[2-(piperazin-1-yl)ethyl]amine

30

The title compound was prepared using an analogous procedure to that described in Example 9. MS (ES<sup>+</sup>) m/e 378 [MH]<sup>+</sup>.

**EXAMPLE 17**

*N*-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[2-(morpholin-4-yl)ethyl]amine

- 5           The title compound was prepared using an analogous procedure to that described in Example 9. MS (ES<sup>+</sup>) m/e 379 [MH]<sup>+</sup>.

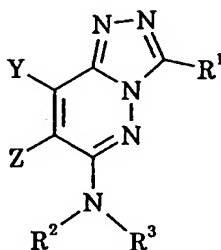
**EXAMPLE 18**

- 10   *N*-(7-Cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[2-(pyridin-2-yl)ethyl]amine

          The title compound was prepared using an analogous procedure to that described in Example 9. MS (ES<sup>+</sup>) m/e 371 [MH]<sup>+</sup>.

**CLAIMS:**

1. A compound of formula I, or a salt or prodrug thereof:



5

(I)

wherein

Y represents hydrogen or C<sub>1-6</sub> alkyl;

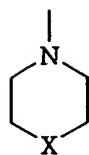
10 Z represents C<sub>1-6</sub> alkyl, C<sub>3-7</sub> cycloalkyl, C<sub>4-7</sub> cycloalkenyl, aryl, C<sub>3-7</sub> heterocycloalkyl, heteroaryl or di(C<sub>1-6</sub>)alkylamino, any of which groups may be optionally substituted;

R<sup>1</sup> represents C<sub>3-7</sub> cycloalkyl, phenyl, furyl, thienyl or pyridinyl, any of which groups may be optionally substituted;

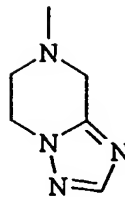
R<sup>2</sup> represents hydrogen or C<sub>1-6</sub> alkyl; and

15 R<sup>3</sup> represents hydrogen; or C<sub>1-6</sub> alkyl, C<sub>3-7</sub> cycloalkyl(C<sub>1-6</sub>)alkyl, propargyl, aryl(C<sub>1-6</sub>)alkyl, C<sub>3-7</sub> heterocycloalkyl(C<sub>1-6</sub>)alkyl or heteroaryl(C<sub>1-6</sub>)alkyl, any of which groups may be optionally substituted; or

20 R<sup>2</sup> and R<sup>3</sup> are taken together with the intervening nitrogen atom to form a ring of formula (a) or (b):



(a)



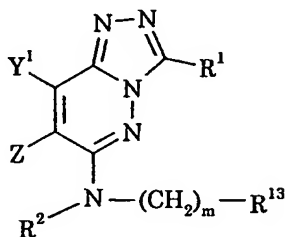
(b)

wherein

X represents oxygen, sulphur or N-R<sup>4</sup>, in which

5 R<sup>4</sup> represents hydrogen or C<sub>1-6</sub> alkyl.

2. A compound as claimed in claim 1 represented by formula IIA, and salts and prodrugs thereof:



(IIA)

wherein

Y<sup>1</sup> represents hydrogen or methyl;

Z, R<sup>1</sup> and R<sup>2</sup> are as defined in claim 1;

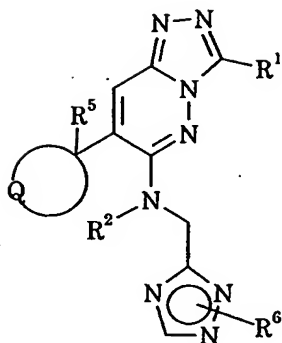
15 m is 1, 2 or 3; and

R<sup>13</sup> represents aryl or heteroaryl, either of which groups may be optionally substituted by one or more substituents.

3. A compound as claimed in claim 2 represented by formula IIB, and pharmaceutically acceptable salts thereof:

20





(IIB)

wherein

R¹ and R² are as defined in claim 1;

5 Q represents the residue of a cyclopropyl, cyclobutyl, cyclopentyl or cyclohexyl ring;

R⁵ represents hydrogen or methyl; and

R⁶ represents hydrogen or methyl.

10 4. A compound selected from:

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-(1-methyl-1*H*-1,2,4-triazol-3-ylmethyl)amine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N,N*-dimethylamine;

15 *N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-methyl-*N*-(1-methyl-1*H*-1,2,4-triazol-3-ylmethyl)amine;

7-cyclobutyl-6-(5,6-dihydro-8*H*-1,2,4-triazolo[1,5-*a*]pyrazin-7-yl)-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazine;

7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-ylamine;

20 *N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-methylamine;

7-cyclobutyl-6-(morpholin-4-yl)-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-(2-methoxyethyl)amine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-(pyridin-2-ylmethyl)amine;

*N*<sup>*o*</sup>-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N,N*-dimethylethane-1,2-diamine;

5 *N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[3-(morpholin-4-yl)propyl]amine;

(±)-*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[2-(1-methylpyrrolidin-2-yl)ethyl]amine;

10 *N*<sup>*o*</sup>-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N,N*-dimethylpropane-1,3-diamine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[3-(imidazol-1-yl)propyl]amine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[3-(pyrrolidin-1-yl)propyl]amine;

15 1-[3-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-ylamino)-propyl]pyrrolidin-2-one;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[2-(piperazin-1-yl)ethyl]amine;

20 *N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[2-(morpholin-4-yl)ethyl]amine;

*N*-(7-cyclobutyl-3-phenyl-1,2,4-triazolo[4,3-*b*]pyridazin-6-yl)-*N*-[2-(pyridin-2-yl)ethyl]amine;

and salts and prodrugs thereof.

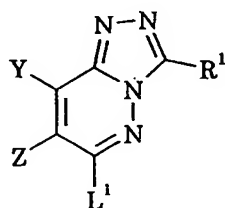
25           5.     A pharmaceutical composition comprising a compound of formula I as defined in claim 1 or a pharmaceutically acceptable salt thereof or a prodrug thereof in association with a pharmaceutically acceptable carrier.

6. The use of a compound as claimed in any one of claims 1 to 4 for the manufacture of a medicament for the treatment and/or prevention of anxiety.

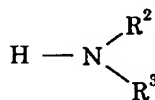
5 7. The use of a compound as claimed in any one of claims 1 to 4 for the manufacture of a medicament for the treatment and/or prevention of convulsions.

10 8. A process for the preparation of a compound as claimed in claim 1, which comprises:

(A) reacting a compound of formula III with a compound of formula IV:



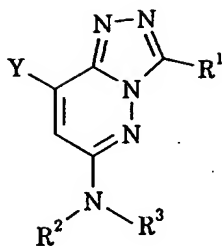
(III)



(IV)

wherein Y, Z, R¹, R² and R³ are as defined in claim 1, and L¹ represents a suitable leaving group; or

20 (B) reacting a compound of formula Z-CO<sub>2</sub>H with a compound of formula VII:

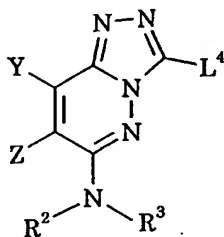


(VII)

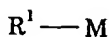
wherein Y, Z, R¹, R² and R³ are as defined in claim 1; in the presence of silver nitrate and ammonium persulphate; or

5

(C) reacting a compound of formula VIII with a compound of formula IX:



(VIII)



(IX)

10

wherein Y, Z, R¹, R² and R³ are as defined in claim 1, M represents -B(OH)₂ or -Sn(Alk)₃ in which Alk represents a C₁-₆ alkyl group, and L⁴ represents a suitable leaving group; in the presence of a transition metal catalyst; and

15

(D) subsequently, if desired, converting a compound of formula I initially obtained into a further compound of formula I by standard methods.

20

9. A method for the treatment and/or prevention of anxiety which comprises administering to a patient in need of such treatment an

effective amount of a compound of formula I as defined in claim 1, or a pharmaceutically acceptable salt thereof or a prodrug thereof.

10. A method for the treatment and/or prevention of convulsions  
5 which comprises administering to a patient in need of such treatment an effective amount of a compound of formula I as defined in claim 1, or a pharmaceutically acceptable salt thereof or a prodrug thereof.

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 99/00105

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 C07D487/04 A61K31/50 C07D519/00 //(C07D487/04,249:00,  
237:00),(C07D519/00,487:00,487:00)

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C07D A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 1 589 237 A (AMERICAN CYANAMID) 7 May 1981 see page 8, line 14 - page 10, line 13 & DE 27 41 763 A cited in the application	1,5
P,A	WO 98 04559 A (MERCK) 5 February 1998 see claims 1,10,11	1,5



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

### \* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

12 May 1999

Date of mailing of the international search report

25/05/1999

Name and mailing address of the ISA

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Authorized officer

Alfaro Faus, I

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/GB 99/00105

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 9 and 10  
because they relate to subject matter not required to be searched by this Authority, namely:  
Remark: Although claims 9 and 10  
are directed to a method of treatment of the human/animal  
body, the search has been carried out and based on the alleged  
effects of the compound/composition.
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such  
an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all  
searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment  
of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report  
covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is  
restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 99/00105

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